

METHOD AND APPARATUS FOR TESTING OPTICAL NETWORKS

DESCRIPTION

5 FIELD OF THE INVENTION

The invention relates to a method and apparatus for testing optical networks and is especially, but not exclusively, applicable to a method and apparatus for measuring signals in optical transmission lines of passive optical networks.

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BACKGROUND ART

As the cost of optical fiber and associated components decreases, new telecommunications network deployments increasingly use optical fiber from the edge of a core network to a location at or very close to the end user. Such so-called FTTX (Fiber-to-the-X; where X is the home, the office, the building, the curb, etc.) installations are usually based on a passive optical network (PON) architecture, where a terminal at the core-network edge (Optical Line Terminal - OLT) broadcasts signals downstream along an fiber-optic cable to a N-port splitter, and each of the ports then terminates at an optical network terminal (ONT) located at a respective one of the end users' premises. Typically, downstream signals are at either of two wavelengths, vis. 1490nm for the downstream transmission of digital data and 1550nm for the transmission of cable television (CATV) signals, while each end user's optical network terminal (ONT) transmits upstream data signals at a wavelength of approximately 1310 nm. It should be noted that the CATV signals are often transmitted in analog format.

An asynchronous transfer mode (ATM) or similar protocol is often used to encode the downstream and upstream data signals. The OLT includes in the downstream 1490-nm signals synchronization signals which permit each of the 30 ONTs to send its upstream (1310-nm) signals in its own unique time slot so as to avoid interference with signals from other ONTs connected on the PON. For this reason, as well as for reasons of eye safety, there is no 1310-nm transmission

from ONTs when the fiber link is disconnected, thereby preventing reception of the 1490-nm downstream-data signal.

Field maintenance of such FTTX installations requires low-cost and easy-to-use diagnostic test instruments to measure the signals. An example of such 5 diagnostic test instruments is an optical power meter that can independently measure the power at the distinct downstream and upstream signal wavelengths (e.g. 1310 nm, 1490 nm, 1550 nm). During a repair call, the results of such a measurement could indicate the source of possible trouble in the network or in the end-user's connection. It is also known to use optical spectrum analyzers 10 (OSA) to measure optical power at several wavelengths at the same time.

A disadvantage of each of these instruments is that it is a one-port device that only measures the power if the signals at the different wavelengths are propagating in the same direction along the fiber. In the case of the OSA, a further disadvantage is that the instrument is generally much too costly and 15 complicated for routine field applications.

DISCLOSURE OF THE INVENTION

The present invention seeks to eliminate, or at least mitigate, the disadvantages of the prior art, or at least provide an alternative and, to this end, 20 there is provided a portable instrument for measuring parameters, e.g. optical power, of analog or digital optical signals that concurrently are propagating bi-directionally in an optical transmission path between two elements, such as network elements of a passive optical network, at least one of which will not transmit its optical signals if continuity of the path is not maintained.

According to one aspect of the present invention, there is provided a 25 portable instrument for measuring parameters of optical signals propagating bi-directionally in an optical transmission path between first and second elements at least one of which will not transmit its optical signals if continuity of the path is not maintained, the instrument comprising first and second connector means for connecting the instrument into the optical transmission path in series therewith, 30 coupler means having first and second ports connected to the first and second connector means, respectively, so that a path therebetween within the coupler

completes the optical transmission path, a third port for outputting a portion of each optical signal received via the first port and a fourth port for outputting a portion of each optical signal received via the second port, detection means coupled to the third and fourth ports for converting the optical signal portions into corresponding electrical signals, processing means for processing the electrical signals to provide desired measurement values, and output means for indicating measurement results.

5 Preferably, the output means comprises display means for displaying measured values of the parameters.

10 Where at least one of the optical signals comprises parts having different wavelengths, the instrument may further comprise wavelength discrimination means for distinguishing corresponding parts of the corresponding optical signal portion according to wavelength, the detection means and processing means detecting and processing the two different signal parts separately. The detection means then may comprise two detectors, each for detecting a respective one of the optical signal parts

15 Where the optical signals are analog, the processing means may be arranged to extract the time-averaged optical power of the signal.

20 Where the optical signals comprise bursts alternating with lulls, the processing means may be arranged to extract the optical power of the bursts

25 If the optical signals comprise bursty digital signals, the processing means may further be arranged to extract the optical power of the bursts averaged over the duration of the burst. More particularly, where the instrument is to be used for measuring power of optical signals comprised of "bursty" data streams (such as the ATM data signals), the detector means may be arranged to extract the power only from the data bursts and not from any intervening series of digital zeros (i.e. lack of signal). Such bursty data streams are typical of both the upstream data sent by an optical network terminal (ONT) to a plurality of optical line terminals (OLTs) of a passive optical network (PON), and by the OLT to the plurality of ONTs.

30 The signal processing means may be custom circuitry and/or a suitably-programmed microcomputer

According to a second aspect of the invention, there is provided a method of measuring parameters of optical signals propagating bi-directionally in an optical transmission path between elements, at least one of the elements not transmitting its optical signals if continuity of the transmission path is not

5 maintained, the method comprising the steps of (i) connecting into the optical transmission path first and second ports of a coupler so that a path through the coupler between the first and second ports is in series with the optical transmission path and conveys said bi-directional signals therebetween; (ii) detecting at a third port of the coupler a portion of a said optical signal

10 propagating in one direction in the path and providing a corresponding first electrical signal; (iii) detecting at a fourth port of the coupler a portion of a said optical signal propagating in the opposite direction in the path and providing a corresponding second electrical signal; and (iv) processing said first and second electrical signal to provide desired measurements.

15 Where at least one of the optical signals comprises parts having different wavelengths, the method may further comprise the step of distinguishing the corresponding different parts of the corresponding optical signal portion according to wavelength, and the detecting and processing steps then may detect and process the two different signal parts separately

20 Various objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description, of a preferred embodiment of the invention which is described by way of example only with reference to the accompanying drawings.

25 **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a simplified block schematic diagram of a portion of a passive optical network;

Figure 2 is a simplified block schematic diagram of a power meter embodying the present invention inserted into a branch of the network; and

30 Figure 3 is a detail view illustrating a modification

DESCRIPTION OF PREFERRED EMBODIMENTS

A portion of a passive optical network shown in Figure 1 comprises a central office optical line terminal (OLT) 10 coupled by a 1:9 splitter 12 to a plurality of optical network terminals (ONT) 14/1 to 14/9, each coupled to a 5 respective one of the nine ports of the splitter 12 by one of a corresponding plurality of optical waveguides 16/1 to 16/9. (It should be noted that, although nine terminals and a nine-port splitter are shown for convenience of illustration, there could be more or fewer in practice.) The terminals use asynchronous transfer mode (ATM) or similar protocol to encode the downstream (OLT to 10 ONTs) and upstream (ONTs to OLT) digital data signals. OLT 10 broadcasts to the ONTs 14/1 to 14/9 downstream data at a wavelength of 1490-nm and downstream cable television signals at a wavelength of 1550-nm and, in known manner, encodes the 1490-nm signals for synchronization purposes, the encoding being decoded by the ONTs and used to permit each of the ONTs 14/1 to 14/9 to 15 send upstream, to the OLT 10, 1310-nm digital optical data signals in its own unique time slot so as to avoid interference with signals from other ONTs connected to the same OLT 10.

If they do not receive the downstream signals, and hence the synchronization information, the ONTs cannot normally transmit. For a field 20 technician to make measurements of all three signals, therefore, it is necessary for the ONTs 14/1 to 14/9 to continue receiving the downstream signals from the OLT 10.

A test instrument 18 which allows the upstream and downstream optical signals to continue propagating, while measuring the power of the optical signals 25 at all three wavelengths, will now be described with reference to Figure 2, which shows the instrument 18 connected into branch waveguide 16/9 between the splitter 12 and ONT 14/9. The test instrument 18 comprises a casing 20 having a first 22 and second 24 bulkhead connectors shown coupled to the splitter 12 and ONT 14/9, respectively. Connector 24 is shown connected to the ONT 14/9 by a 30 short jumper 26.

Within the power meter casing 22, the receptacles 22 and 24 are connected to first and second ports 28 and 30, respectively, of a 2 x 2 optical

coupler 32, having an approximately 80:20 splitting ratio which ratio is approximately the same at all the wavelengths to be measured (i.e. 1310 nm, 1490 nm, 1550 nm).

5 Thus, coupler 32 splits each signal received at ports 28 and 30 into two parts with a ratio of 80:20. The 80 per cent signals are each routed back to the other of the two connectors 22 and 24 while the 20 per cent signals are each routed to one of third and fourth ports 34 and 36, respectively, of the coupler 32.

Port 34, which receives the 20 per cent portion of the signal from the ONT 14/9, is connected by way of a 1310 nm bandpass filter 62 to a first detector 10 38 for detecting light at wavelengths nominally at 1310 nm. Port 36, which receives 20 per cent of each of the 1490-nm and 1550-nm optical signals from the OLT 10, is coupled to a 1x2 optical splitter 40, having an approximately 90:10 splitting ratio that is approximately the same at all downstream wavelengths to be measured (i.e. 1490 nm, 1550 nm)

15 The 90 per cent signals from splitter 40 are routed via the corresponding output optical fiber from the optical splitter 40 to a second bandpass filter 64, passing light within an approximately 15-nm wavelength band centered about 1490 nm and substantially attenuating light outside of this band (e.g. attenuation of greater than 40 dB at 1550 nm). The output of the second bandpass filter 64 is 20 routed to a second detector 42, which then detects light nominally at 1490 nm.

The 10 per cent signals from splitter 40 are routed via the corresponding output optical fiber to a third bandpass filter 66, passing light within an approximately 25-nm wavelength band centered about approximately 1550 nm and substantially attenuating light outside of this band (e.g. greater than 20 dB 25 for analog CATV signals, greater than 40 dB for digital CATV signals). The output of the third bandpass filter 66 is coupled to the third detector 44, which then detects light nominally at 1550 nm.

30 The three detectors 38, 42 and 44 supply the corresponding electrical signals to an electronic processing unit 46 which comprises a set of three similar amplifiers 48, 50 and 52 for amplifying the electrical signals from detectors 38, 42 and 44, respectively. Peak detectors 54 and 56 detect peak power of the 35 amplified electrical signals from amplifiers 48 and 50, respectively, and supply

the peak power measurements to an analog-to-digital converter 58 which converts them to corresponding digital signals which it supplies to a display unit 60 for display of the measurements in a conventional manner. The amplified signal from amplifier 52 is supplied directly to the analog-to-digital converter 58, 5 i.e., without peak detection, to provide a measure of average optical power.

Typically, the field technician will disconnect the link 16/9 to ONT 14/9 at the home/premise etc. of the end-user at an existing "connectorized" coupling. The connector on the upstream part of the link 16/9 will then be connected to a specified one (22) of the two bulkhead connectors on the instrument, and the 10 connector on the jumper 26 will be connected to the other. Of course, if a connectorized coupling between parts of the link is available, the jumper 26 may not be needed.

While the cable is disconnected, emission of the upstream data signals at wavelength 1310 nm by the ONT 14/9 will normally cease, and will then 15 recommence when the two connectors are connected to their respective bulkhead connector receptacles on the test instrument. Measurements can then be taken.

The fact that there will be a temporary disruption in the line as the instrument 18 is inserted is not normally important, since it would normally be used in service calls where a problem has already been indicated by the customer.

Once the test instrument is inserted into the line, between the splitter 12 and the selected one of the ONTs 14/1 to 14/9 (see Figure 1), 80% of the downstream data and video signals (e.g. at 1490nm and 1550 nm, respectively) will pass directly through to the ONT. The ONT, thus synchronized via the received data signal, will then be able to emit its upstream (e.g. 1310-nm) data 25 signal, 80% of which will be sent upstream to the OLT 10, the other 20 % being diverted to the detector 38.

It will be appreciated that the ratio of the coupler 32 need not be 80.20. Embodiments of the invention may employ different ratios. Generally, lower ratios entail more attenuation while higher ratios are more polarization-dependent. It should be noted, however, that preferred couplers are available commercially that have a particular band of wavelengths for which their ratios 30 are substantially wavelength and polarization independent.

It will be appreciated that the invention is not limited to the measurement of optical power and to power meters but could be applied to the measurement of other parameters, such as optical spectrum, bandwidth utilization in the transmission path or link, and so on. For example, the coupler 32 could be

5. combined with an optical spectrum analyzer which replaces the optical splitter 40, the bandpass filters 62, 64, 66, detectors 38, 42 and 44, processing means 46, and the display 60, and a 2 x 1 coupler added to couple the ports 34 and 36 of the 2 x 2 coupler 32 to the single input port of the OSA, thereby combining the two 20% signal portions.

10 It will also be appreciated that the 2 x 1 coupler inherently will introduce a loss, typically of 50% or more. Of course, instead of the OSA, an alternative single-port device coupled to a 2 x 1 coupler could replace the components 38 - 66 of Figure 2

15 The bandpass filter 62 serves as a discrimination filter and is desirable to avoid undesired effects caused by optical back reflection of the 1550 nm signal which can be acute when measurements are taken close to the OLT 10. It may be omitted, however, if the apparatus will normally be used close to the ONT terminal(s).

20 As illustrated in Figure 3, the splitter 40 and bandpass filters 64 and 66 may be replaced by a wavelength demultiplexer 68 (e.g. a low optical crosstalk WDM coupler) which separates the signals according to their respective wavelengths and supplies them to the detectors 42 and 44. It will be noted that Figure 3 omits the bandpass filter 62, but it may be included for the reasons discussed above.

25 The electronic processing unit 46 may be digital rather than analog, in which case it could be a suitably programmed microcomputer.

INDUSTRIAL APPLICABILITY

Portable test instruments embodying the present invention may be 30 inexpensive and easy-to-use. Ease of use is especially critical when they are used for testing FTTX networks since the maintenance field technicians are generally

the same personnel who maintain wire telephone connections and rarely have had significant training in fiber-optic technology.

Although an embodiment of the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of 5 illustration and example only and not to be taken by way of the limitation, the spirit and scope of the present invention being limited only by the appended claims.